AMATEUR SATELLITE REPORT

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AMSAT's® *Newsletter for the Amateur Radio Space Program*

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Annual Meeting In Dallas Hailed

If comments received from attendees are indicative, the Fourth Annual Space Symposium and 1986 AMSAT Annual General Meeting held in Dallas the weekend of November 7, 8 and 9 was likely the best ever. Attendees from five continents mixed among the 150 guests at the meeting, the high point of AMSAT's annual calendar.

The events began Friday evening with a Texas-style barbecue. Saturday saw an all-day symposium while the evening had the Banquet, Keynote speech, Annual Meeting and awards presentation on tap. The evening was culminated by the featured banquet prize giveaway where more than $3,000 in prizes were awarded. The following is a summary of the weekend event.

About 15 early arrivals toured local electronic surplus houses Friday morning and afternoon. Later they joined other arrivals in a Friday afternoon social hour at the local watering hole. Then all those who had arrived (about 80 persons) were treated to a fine indoor buffet-style barbecue.

At 8:00 AM Saturday the Space Symposium began with welcoming remarks by President Vern "Rip" Riportella, WA2LQQ. Speakers and their topics included: JA1ANG (FO-12); W3IWI (FO-12 modem); ZS6AKV and ZS6ALN (Phase 3C Mode S antenna); KA9Q (computer controlled AFC on the IC-271/471 radios); KA9Q read a paper by G3RUH on satellite attitude determination; N4HY (orbit options); WB6JNN (ACSSB progress); WB5FIV (Houston packet satellite concepts); N5AHD (UoSAT telemetry); W3GEY (Phase 4 overview); G3YJO (UoSAT status and future projects); W3XO and W5DID (future manned space radio opportunities); WØRPK (AO-10 status and the new IHU and memory for Phase 3C); W4RI (digital satellite communications).

Over 120 filled the lecture hall at the Dallas/Fort Worth Hilton Hotel to capacity. Astronaut Tony England, WØORE, attending as a private citizen with his wife Kathy, later noted the papers read were impressive and generally excellent. Tony serves NASA as Chief Scientist on the Space Station program. He was among numerous attendees who asked questions of the presenters. He also is part of the team seeking to place an Amateur Radio station on board the Space Station as part of the joint AMSAT/ARRL Space Station Amateur Radio (SSAR) project.

After the Space Symposium the group, many joined by their spouses, met in a pleasant outdoor patio adjacent to the pool for a bit of attitude adjustment. The banquet was served poolside and was in all respects excellent.

Soon it was time for the Annual Meeting. Returning to the huge lecture hall, the meeting began with greetings from conference Chairman Al Brinckerhoff, WB5PMR. He introduced WA2LQQ who in turn introduced some of the many in attendance. Among the many organizations represented were AMSAT Mexico represented by President David Liberman, XE1TU; Brazil AMSAT by President Junior DeCastro, PY2BJO; JAMSAT by President Harry Yoneda, JA1ANG; SA AMSAT by President Hans Van de Groenendahl, ZS6AKV; Project OSCAR by President Jim Eagleson, WB6JNN.

Marc Chartrand of the National Space Society spoke to an AAS session in Boulder on 29 October.

WA2LQQ then introduced Keynote Speaker Dr. Martin Davidoff, K2UBC. Marty traced the past 25 years of OSCAR progress in a provocative photo slide presentation reminiscing the roots of OSCAR satellites.

The the Annual Meeting itself began with some vital announcements. First, the results of the Director's election were announced as follows:

Tom Clark, W3IWI	1061 votes (re-elected)
Vern Riportella, WA2LQQ	943 votes (re-elected)
Harry Yoneda, JA1ANG	560 votes (re-elected)
Ralph Wallio, WØRPK	498 votes (elected first alternate Director)
John Champa, K8OCL	354 votes (elected second alternate Director)
Andy MacAllister, WA5ZIB	305 votes
Joe Flaska, WBØRLY	292 votes
Gordon Hardman, KE3D	202 votes

According to the vote tallymaster, 1426 ballots were cast. The elected Directors will serve two-year terms. Alternate Directors serve one year.

Next, WA2LQQ reported the status of AMSAT as solvent, having slightly under-run its 1986 budget if year-end forecasts hold. He forecast a 1987 budget cap of about $220,000, the exact amount to be discussed at the Board meeting the next day. He then listed some prospective 1987 organizational goals. They included:

- Bring in new managers, train and task them
- Strengthen field organization to provide better convention support
- Launch Phase 3C and commence operations
- Organize an international conference for AMSAT organizations worldwide
- Upgrade AMSAT management skills
- Enable sophisticated development plans and programs
- Demonstrate advanced ACSSB and digital voice techniques
- Resume ZRO tests, Project Linkup and Gateway on Phase 3C, Mode S
- Complete Phase 4 Studies for informed decision by November 1987

Then WA2LQQ showed some viewgraphs of a new organizational structure which included several new positions designed to staff the 1987 goals effort. The new positions included Vice Presidents of Field Operations, Information Services and Development.

The drawing for the membership renewal prizes then took place. Winning KLM antennas for their AMSAT membership renewals were Glen Moore, WBØFGM and John Borg, KF4PB.

The annual awards presentation then commenced. Presenting the awards for technical achievement was VP-Engineering Jan King, W3GEY. Jan cited first the Colorado Phase 3C Integration Team for their efforts in meeting all milestones in that effort this past year at the AMSAT integration facility in Golden Colorado. Accepting on behalf of the Phase 3C integration team was a key contributor to that effort, Ed Means, WØVO. Ed was chiefly responsible for the wiring harness. He was quick to point out the outstanding contributions of the entire integration team.

Next, Jan presented a Technical Achievement Award to the Phase 3C Mode S Design and Construction Team headed by Bill McCaa, KØRZ. Jan accepted the award on behalf of this team which managed to get this exciting payload shoe-horned into P3C.

The two team awards consisted of engraved plaques. Each of the team members of the P3C Integration and Mode S teams will receive a personalized certificate of recognition for their achievements Jan explained.

Then W3GEY awarded Technical Achievement awards to the following individuals:

Joe Bijou, WB5CCJ and Dick Allen, W5SXD, for their masterful tracking software products called GRAFTRAK II and Silicon Ephemeris.

Phil Karn, KA9Q, for his satellite ranging techniques and orbital analysis.

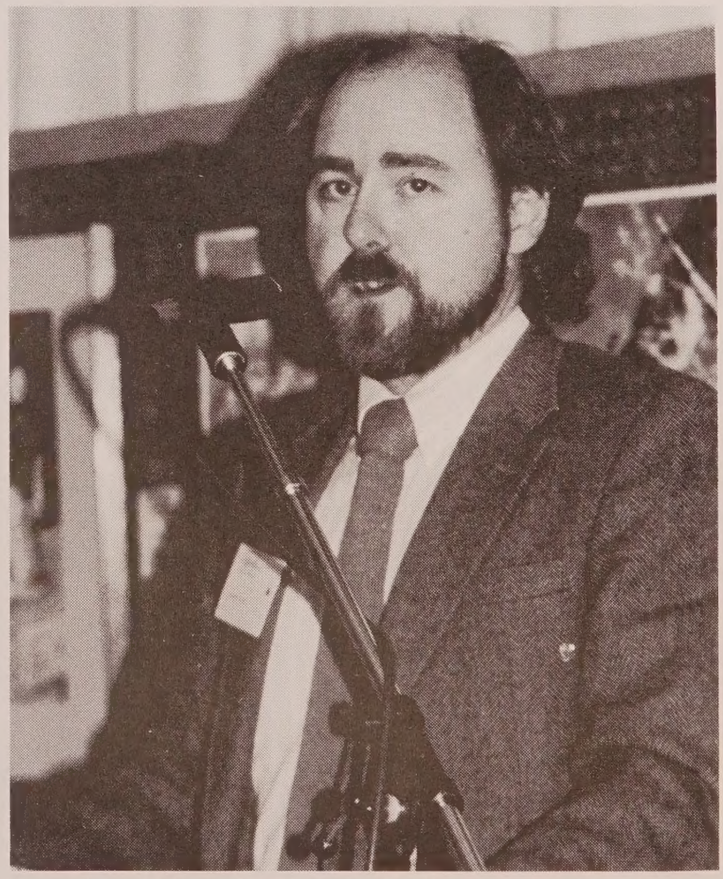
Jim Eagleson, WB6JNN, for his continuing work in ACSSB techniques.

Then, to present the Field Operations Achievement awards, Mike Crisler, N4IFD, Chief Area Coordinator, came to the podium. He presented the Field Operations Awards to three outstanding Area Coordinators:

Dick Beers, WD9IIC, Illinois Area Coordinator in the Chicago area.

Keith Pugh, W5IU, Texas Area Coordinator in the Fort Worth area.

Byron Lindsey, W4BIW, Georgia Area Coordinator in the Atlanta area. (Mack Jordan, W4DAQ, Alabama Area Coordinator, accepted on behalf of W4BIW.)



Leonard David, formerly with the National Commission on Space at an AAS session on Public Support in Boulder 29 October.

Next, VP-Operations Ralph Wallio, WØRPK, rose to present the Operations Achievement Awards for 1986. The awardees included: Mike Crisler, N4IFD. (WA2LQQ previously had announced that Mike had been promoted to VP-Field Operations, a new position, in recognition of superior performance).

Then WØRPK presented plaques to the entire AO-10 command team including:

Ian Ashley, ZL1AOX
Graham Ratcliff, VK5AGR
Randy Smith, VE1SAT
Ron Dunbar, WØPN
Peter Guelzow, DB2OS
Hanspeter Kuhlen, DK1YQ.

The plaques to the command team were made, Ralph added, "On behalf of the entire AO-10 user community".

An award went to Bob Diersing, N5AHD, for his outstanding work on the AMSAT Software Exchange, decoding UoSAT telemetry and the *AMSAT Technical Journal*. An award was presented to Larry Kayser, WA3ZIA, for his many contributions spanning more than a decade and most recently his work with the UO-11 DCE. Accepting the award for WA3ZIA was John Henry, VE2VQ.

WA2LQQ then presented a special Space Operations Achievement Award to Tony England, WØORE, on his SAREX project on Shuttle mission 51F last year. Tony said he would accept the award on behalf of all "those who did so much more than me on the SAREX project."

Finally, the President's 1986 Special Achievement Awards were presented by WA2LQQ. First to receive his plaque was Dick Daniels, W4PUJ, for more than a decade in the precision work of building OSCARs. Then, Paul Rinaldo, W4RI, received a 1986 President's Special Achievement Award for his enormous contributions to Amateur Radio. Paul's immediate supervisor at ARRL HQ, Dave Sumner, K1ZZ, ARRL Executive Vice President, sent a special congratulatory note to be read concurrent with the presentation to Paul. The final award of the evening went to AMSAT Chairman of the Board John Browning, W6SP, for his outstanding leadership in AMSAT affairs over more than half a decade.

Bob Twiggs, NUSAT 1 Project Manager, at the AAS conference in Boulder, CO 27 October. NUSAT 1 was the first GAS can ejected payload to fly on shuttle. It may be a forerunner of one or more AMSAT projects.

Gil Moore of Morton-Thiokol chaired the Small Payloads and Space Science session of the AAS Conference in Boulder on 27 October.

The prize awards provided a dramatic climax to the evening. Winning the top prize, the ICOM IC-1271A 1.3 GHz all-mode transceiver was Billy Overman, K4SNF of Rockwell, NC. (A complete list of the prize winners will be published in *ASR* #138).

On Sunday morning several informal sessions were held. A pre-amp calibration bench was established and proved very popular. A discussion on Phase 4 led by W3GEY had a packed house. After hearing Jan speak about Phase 4, there was absolute unanimity among the nearly 100 gathered that the Phase 4 growth path was the way to go. Jan's powerful arguments convinced even the fence-sitters in the audience.

Later Sunday morning, the Board of Directors met in the first of its two sessions. The second was held Monday. Key decisions of the Board included the following:

The 1987 Officers are:

WA2LQQ, President
K8OCL, Executive Vice President
W3GEY, VP-Engineering
WØRPK, VP-Operations
KB4ZJ, Treasurer
M. Saragovitz, Secretary

Additionally, the following officers, beyond those called for by the Bylaws, were elected:

W6SP, Chairman of the Board
N4IFD, VP-Field Operations

The following new positions were concurred in but are presently unfilled:

VP-Information Services
VP-Development

The Board was asked to re-consider the name change decided last year (AMSAT-North America). However, the Board declined to reverse its previous decision and emphasized its intent that the name AMSAT NA shall be used as voted last year. The Board directed the President to implement the decision forthwith.

The Fifth Annual Space Symposium and 1987 Annual Meeting will be held in Dearborn, Michigan. The Board decided this after a presentation by K8OCL and K8MU. Larry Koziel, K8MU, will be the Project Manager.

The Board heard presentations on Phase 4 studies and a Packet Technology Satellite Experiment from Houston. The Board indicated both seemed worthy of support but awaits finalization of the budget to determine the specific level of support. The Budget inputs will be re-submitted for consideration by the end of November. The Board did agree on the Treasurer's recommendation that the budget be tacked at $215,000 for 1987 based on income projections made by the Treasurer.

The 1987 mid-year Board meeting is being de-coupled from the Dayton Hamvention and will instead be held in the Washington, D.C. area as it was until a couple of years ago.

(The complete and official minutes will be published when available. The foregoing is only the briefest of summaries.)

AMSAT wishes to thank the 1987 Symposium organizers on a superb job. They include:

Al Brinckerhoff, WB5PMR, Chairman
Rusty Reeve, KT5U, Reservations
Ray Hoad, WA5QGD, Prizes
Bill Reed, WD0ETZ, Promotions
Keith Pugh, W5IU, Accommodations
Darrell Crimmins, KG5E, Communications
Bob Stricklin, N5BRG, Speakers and Proceedings

Congratulations to all who made this year's event such an outstanding success! (Symposium photos will appear in *ASR* #138)

Project OSCAR to Fete OSCAR-1 and Its Builders

Project OSCAR, a West Coast USA, organization plans a celebration of the beginning of the Amateur Radio Space Age with a celebration of the event on its 25th anniversary. The celebration will be held on Saturday, December 13, at 2:00 PM at the Space Science Center and Electronics Museum at Foothill College, Los Altos Hills, CA.

Advance reservations are required. A $5.00 donation is requested. Here is your opportunity to meet some of the original members of Project OSCAR who actually built OSCAR-1 and to hear of their experiences designing and constructing this historic spacecraft! You will also be able to see memorabilia and artifacts from the early days of OSCAR. For Reservations or more information: Ross W. Forbes, WB6GFJ, Post Office Box 1, Los Altos, CA, 94023-0001 Telephone: (415) 948-5000 [9 AM - 9 PM PST]

Short Bursts

- Although command stations are making substantial progress in learning what areas in the AO-10 memory have failed and have even succeeded in loading short telemetry routines, the prognosis remains bleak. If the transponder is turned on for use, you may use it ONLY with QRP. Repeat. QRP only!
- A preliminary PSK operating schedule for FO-12 has been released by JARL and JAMSAT. The schedule is being revised as we go to press. Tune to the AMSAT nets for the latest on the operating schedule. Initial Mode JD telemetry tests have proved quite successful as reports from Europe, Asia, South Pacific and America indicate.
- According to G3IOR, RS-5 is operating 1000 to 1400 UTC but is in very bad shape. RS-7 is operating from 0600 to 1000 UTC. Both are shut off on Wednesdays UTC.
- Steve Culp, K8QKY, has been appointed AMSAT Volunteer Coordinator. He replaces WD4FAB who has been named Phase 4 Study Team Administrator.

TAPR FO-12 Modem Update

by Tom Clark, W3IWI

Just a brief update on the FO-12 PSK modem activity here at W3IWI. As I reported earlier, I have been working on the prototype TAPR unit and the demod portion is virtually identical to that published in the August issue of QEX.

An annoying problem of RFI susceptibility that caused the TNC2 to "croak" spontaneously has been fixed by better

Keynote speakers at the AAS meeting 27 October included (l-r): Tom Donahue, National Academy of Science; Jack Kerrebrock, National Space Commission and Assoc. Dean of Engineering, MIT; Richard Johnson, Director, Office of Science and Technology Policy.

shielding. The problem was pickup on the ribbon cable connecting the TNC2 'modem disconnect' header to the PSK modem.

We have been running local loop-back tests involving FT-726R (on 2m or 70cm) and TS-711/811 radios. A few pieces of good news (in the following remember that it makes no difference if you use USB or LSB on either end of the link. The NRZI encoding in packet data involves only data transitions and does not depend on the absolute polarity of the data):

a) The digital AFC works fine on the 711/811 radios. There is no tendency to drop lock or data when stepping. This is very good news since I was concerned about phase discontinuities when stepping. It is a real ball to crank the transmitter to simulate Doppler and watch the receiver follow it. The 811, with its 10 Hz steps seems very well suited to use on PSK.

b) The bandpass filters in the TS-811 seem quite good for 1200 baud PSK. No asymmetry can be found and eye patterns look equally good running the radio on USB or LSB.

c) My FT-726R was modified a couple of years ago when we found that a stock 726 had bad group delay distortion on 1200 baud FSK packets. The mod involved putting in a different ceramic filter, but even with that filter the delay distortion was pretty bad if the radio was on USB, but acceptable on LSB. The old finding on FSK seems to be borne out on PSK — performance on LSB is superior to USB on my unit.

d) Haven't tried other common radios yet. If anyone would like to offer a truly stock FT-726R or an IC-271/471 for the "Consumer's Report" activities, please let me know. Either 2m or 70 cm is OK.

It isn't easy to calibrate weak signal performance of these modems. The scheme which I have been using for evaluation is to compare the noise voltage (sans data) with the signal+noise voltage at the output of the coherent detector when the signal is very weak. With a (S+N)/N voltage ratio just over 3 (i.e. S+N/N = 9-10 dB) I see a Bit Error Rate (BER) of better than 1:10e-3.

The eye patterns indicate that the data filter we are using is close to optimum for the 1200 baud rate (filters throughout demod are 2nd order with cutoff at 900 Hz). The inference is that we are within a couple of dB of the theoretical optimum performance for coherent PSK with the QEX design. A more detailed assessment of these parameters will require considerably more accurate testing procedures.

Demod lockup performance seems quite good. I am able to send normal on/off packets thru the unit with a TXD parameter on a TNC2 of 50 (i.e. 1/2 second) even when signals are weak after the signal has been been tuned to the center of the demod passband by the digital AFC. However, this did require two minor modifications to the QEX circuit to prevent the PLL error integrator (U3a) from running away. First, I replaced U3 with a low offset quad op amp chip (I used a TLC274 Quad CMOS part, Radio Shack #276-1750). Then I found it desirable to add DC stability by shunting the integrator (use the W1 jumper) with a 30-50 Meg resistor.

The QEX article did not describe the Manchester modulator needed. To see what is required, you might read the article by Lyle Johnson (WA7GXD) on page 10 of the September issue of *Packet Radio Magazine*. The design we are working on allows both PSK and Manchester FSK. If you refer to the schematic on page 11 of Lyle's article, to generate PSK you disconnect the upper input to the XOR gate (labelled "2") and feed in a 1600 Hz square-wave signal (we use a NE555 at 3200 Hz and a divider to insure a 50% duty cycle).

Here in the Baltimore/Washington area I have a FO-12 simulator beacon on the air just waiting for somebody else to get a demod working. This weekend it has been on 145.800 sending a PSK "BRAAAAAP" every minute. A couple of the locals have been putting together PSK modulators so that they can send me signals from outside the shack but we have no success to report yet. For this testing W3IWI is QRV on either 2m or 70cm.

AMSAT President Vern "Rip" Riportella, WA2LQQ, speaks before the AMSAT Forum at the ARRL New England Division Convention, Boxboro, Massachusetts, 18 October.

A Significant Anniversary In Massachusetts

by Andrew J. Deskur, KA1M

The number 25 currently holds special meaning for AMSAT as well as for the ARRL New England Division. On the one hand, AMSAT is helping to commemorate 25 years of OSCARs. On the other, this is the 25th year of the ARRL's New England Division.

The ARRL's 1986 New England Division Convention was held in Boxboro, MA on October 18 and 19. The 3500+ attendees were treated to 40 different technical seminars including two sponsored by AMSAT. A crowded commercial exhibit hall and an old fashioned flea market helped season the day's activities.

On Saturday, AMSAT President Vern "Rip" Riportella, WA2LQQ, spoke to a "full-house" about where AMSAT is today and where it is headed. His talk focused on the urgent need for Amateurs to actively use all the spectrum we have allocated to us. He pointed out that portions of the radio spectrum are coveted by commercial interests

which will snatch them if given a chance. What was once considered an RF wasteland has now become valuable real estate. Rip explained that AMSAT's development of the UHF spectrum through satellite construction and use is absolutely essential. Moreover, he urged attendees to become active on UHF and to join the thousands of present Amateur Satellite users moving to the higher bands and to vividly demonstrate worthwhile use of the vast spectrum at our disposal.

On Sunday morning, Eastern Massachusetts Area Coordinator, Andrew Deskur, KA1M, held a seminar on how to get started in using Amateur Satellites. Despite it being a Sunday morning, over 40 people (many with large coffee containers in hand) were in attendance. Following the seminar a good round of questions ensued. It seems that no matter what, we can draw an interested crowd of people who want to know how to get started.

The booth was a constant flurry of activity during the two days. Although the booth was staffed by two and three people at a time, there was little time to chat between each other. Joining Rip and Andy in the booth was Assistant Area Coordinator for Eastern Massachusetts, Paul Haasis N1DBB. Also helping out were John Morley, KA1JMF, Tony Manna, WA1ENO, Ron Maille, KB1KO and Rhode Island Area Coordinator Rick Rosen, K1DS. A number of new members joined up and lots of software was snapped up.

Also presenting a talk at the convention was John DuBois, W1HDX. John presented an interesting update on his work to receive weather pictures from the GOES series weather satellites. John continues to operate virtually the only personal GOES facility in the world. The images he showed were stunning.

All in all, this was quite a memorable 25th for both AMSAT and the ARRL New England Division!

ASR *Spotlight On:* *Martin R. Davidoff, K2UBC*

by Pete Killingsworth, KD7WZ

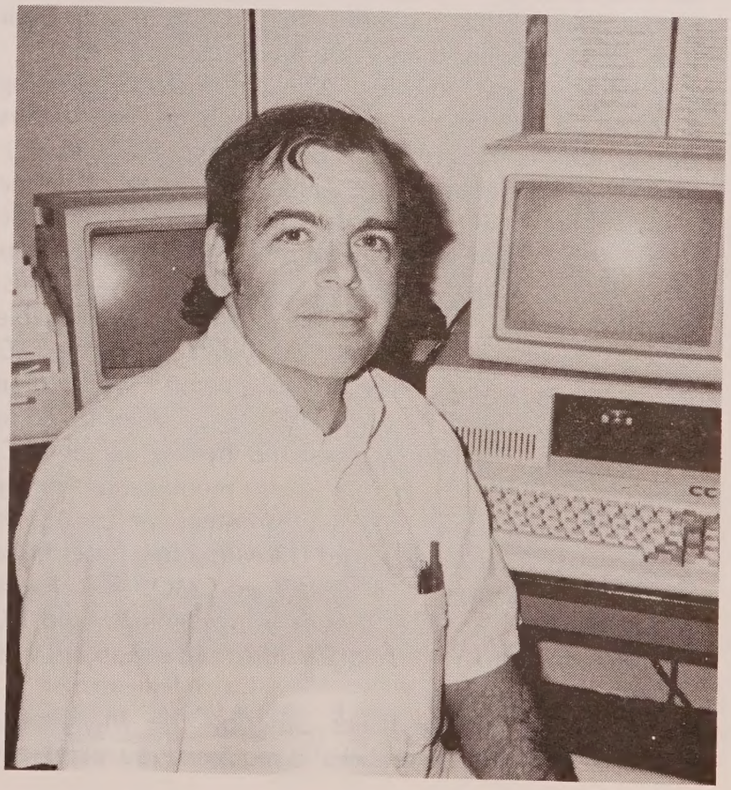
Most of us first came across Dr. Martin Davidoff, K2UBC, by reading his excellent book, *The Satellite Experimenter's Handbook*. This comprehensive text for satellite enthusiasts covers topics ranging from the early days of space flight to basic and advanced operating techniques and even includes a section on building a satellite. His book was first published in 1984 and has now sold over 20,000 copies. It continues to provide a valuable introduction to amateur satellites and has lasting appeal for all satellite operators as a reference book. In his introduction to the book, Marty speculated on whether it would fly on its own merits. Well, it certainly has, and Amateurs around the world continue to be grateful to Marty for his efforts.

Marty is Associate Professor of Mathematics and Computer Science at Cantonsville Community College in Maryland. He holds a Ph.D. in experimental solid state physics. He studied transport phenomena in silicon for his doctoral research but he states that he was, "More interested in designing instrumentation than in doing physics." Marty's wife, Linda has put up with him for some time "with support and good-natured tolerance." She has a Ph.D. in Psychology — it probably helps.

Marty first became interested in satellites when he listened to Sputnik I shortly after it was launched. He was extremely interested in the Amateur Satellite Program from its very beginning but could not operate at first and had to content himself with reading articles in *QST*. He got on the air with OSCAR 6 using a 1955 homebrew W2AZL converter feeding a 1940 vintage National 240-D receiver and an Ameco TX-62 which he bought at a hamfest for $40. His current station consists of Janel converters for 2 meters and 70 cm with a Drake R-599 on receive with various homebrew preamps and antennas. He uses an ICOM IC-211 or the TX-62 on transmit. Marty states that he mostly just listens on the satellites. He is primarily interested in what can be done with simple, homebrew gear.

Marty relates the time in 1964 when he worked on the Columbia University oceanographic research vessel, Vema. "Although it wasn't my responsibility, I would operate CW on the ship's radio station, HPFC, and put the commercial station on the Amateur bands as HP9FC/mm. I always wondered what the 4-inch diameter, floor-to-ceiling pole in front of the HPFC station operating position was until the ship started rolling through plus and minus 30 degrees. You wrapped your left arm around the pole to keep from falling off the chair!"

The most interesting facet of Amateur Radio to Marty is watching how technology changes over the years. Marty tells us, "When I started out in Amateur Radio (was it really 30 years ago?), I thought the real interesting stuff — the switch from spark to CW, the first transatlantic communications — had all taken place. Then I got to listen to the first Amateur SSB stations, hear Sputnik I, watch the birth of the Amateur Satellite Service, follow the invention of the transistor and so forth. I can't predict the future, but I'm sure that Amateur Radio will continue to be as interesting and exciting as it has been in the past."



IARU Measure To Discourage Satellite Interference

The International Amateur Radio Union (IARU) recently held its Region 2 conference in Buenos Aires, Argentina. A resolution was adopted which may help to reduce terrestrial QRM to satellite operations. This is especially significant in view of the interference to FO-12 operations caused by the proliferation of 2-meter FM stations around the world who, apparently unwittingly, uplink their signals through the Mode JA transponder. Here is a "rough" translation of the IARU Region 2 resolution.

Considering:

1) The existence of interference in the uplink and downlink of satellites;

2) That the majority of such interference is caused by stations operating FM;

3) That [the interference] is caused by negligence or ignorance of the operators who do not know that a QSO is in progress in their frequency since they do not listen to intervening stations;

4) That the presence of the FO-12 Satellite operating in mode J (uplink frequency 145 MHz) orbiting at low altitude with a receiver of excellent sensitivity, which allows it to capture and retransmit signals of stations operating inadequately in their uplink frequencies;

5) That such signals are retransmitted to all the area covered by the satellite and occupying each of them a space of 10 or more KHz with the subsequent QRM and unnecessary waste of energy;

RESOLVES:

1) To ask Member Societies, in the way they deem it necessary, to remind radio amateur operators in their countries, the difficulties they cause with emissions produced in frequencies allocated to satellites;

2) To inform appropriately of bands allocated to satellite communications in order to reduce as far as possible their misuse.

John Dubois, W1HDX, presents a talk on weather satellite reception for the ARRL New England Division Convention 18 October.

Andy Deskur, KA1M, in the AMSAT booth at Boxboro 18 October. Andy is a Massachusetts Area Coordinator.

TECH TIP #4: Keplerian Elements for the Sun

by James Miller, G3RUH

I'm often asked how to calculate where the Sun is. Easy; does your satellite tracking software use the familiar Keplerian elements? Right, then all you need is the Keps for the Sun!

The Sun follows a slightly elliptic orbit around the Earth (sorry Copernicus!), inclined at 23.4 degrees, with a period of about 1 year and a semi-major axis of 93 million miles. So just plug these numbers into your regular program....

Satellite:	THE SUN
Epoch Year:	1990
Epoch time:	1.0 Days
i.e. 1990 Jan 01 0000:00 UTC [Mon]	
Inclination:	23.4406 Deg
RA of Node:	0.0 Deg
Eccentricity:	0.0167133
Arg of Perigee:	282.7685 Deg
Mean Anomaly:	357.6205 Deg
Mean Motion:	0.002737778522 Rev/day
Decay Rate:	0.0 Rev/Day^2
Epoch Rev:	1989
Semi Major Axis:	149597870 km

This Keplerian set has been derived from the Astronomical Almanac and will be entirely accurate for amateur purposes until the end of the century — well within 1' of arc. Ideal for calibrating your az-el rotators, EME systems Sun-noise tests, predicting Sun-up, Sun-down and impressing visitors. Happy tracking!

Satellite	OSCAR-9
Catalog number	12888
Epoch time:	86311.01100041
Fri Nov 7 00:15:50.435 1986 UTC	
Element set:	957
Inclination:	97.6540 deg
RA of node:	316.9724 deg
Eccentricity:	0.0001183
Arg of perigee:	318.1298 deg
Mean anomaly:	41.9877 deg
Mean motion:	15.28900814 rev/day
Decay rate:	3.703e-05 rev/day²
Epoch rev:	28278
Semi major axis	6854.198 km
Anom period:	94.185312 min
Apogee:	486.222 km
Perigee:	484.600 km
Ref perigee:	3232.00337189
Fri Nov 7 00:04:51.331 1986 UTC	
Beacon:	145.8250 MHz

Satellite	RS-7
Catalog number	13001
Epoch time:	86310.21414812
Thu Nov 6 05:08:22.397 1986 UTC	
Element set:	282
Inclination:	82.9654 deg
RA of node:	22.5374 deg
Eccentricity:	0.0022806
Arg of perigee:	32.0531 deg
Mean anomaly:	328.1935 deg
Mean motion:	12.08700109 rev/day
Decay rate:	1.3e-07 rev/day²
Epoch rev:	21562
Semi major axis	8017.662 km
Anom period:	119.136251 min
Apogee:	1663.735 km
Perigee:	1627.165 km
Ref perigee:	3231.22145774
Thu Nov 6 05:18:53.948 1986 UTC	

Satellite	OSCAR-11
Catalog number	14781
Epoch time:	86308.75175556
Tue Nov 4 18:02:31.680 1986 UTC	
Element set:	181
Inclination:	98.1308 deg
RA of node:	13.6222 deg
Eccentricity:	0.0014758
Arg of perigee:	82.5502 deg
Mean anomaly:	277.7351 deg
Mean motion:	14.62083244 rev/day
Decay rate:	3.25e-06 rev/day²
Epoch rev:	14290
Semi major axis	7061.667 km
Anom period:	98.489604 min
Apogee:	714.549 km
Perigee:	693.706 km
Ref perigee:	3229.76738488
Tue Nov 4 18:25:02.53 1986 UTC	
Beacon:	145.8260 MHz

Satellite	RS-5
Catalog number	12999
Epoch time:	86311.19322740
Fri Nov 7 04:38:14.847 1986 UTC	
Element set:	362
Inclination:	82.9662 deg
RA of node:	28.9451 deg
Eccentricity:	0.0011597
Arg of perigee:	117.5884 deg
Mean anomaly:	242.6426 deg
Mean motion:	12.05063605 rev/day
Decay rate:	1.3e-07 rev/day²
Epoch rev:	21509
Semi major axis	8033.794 km
Anom period:	119.495767 min
Apogee:	1681.512 km
Perigee:	1662.879 km
Ref perigee:	3232.22027931
Fri Nov 7 05:17:12.132 1986 UTC	

Satellite	OSCAR-10
Catalog number	14129
Epoch time:	86312.44034196
Sat Nov 8 10:34:05.545 1986 UTC	
Element set:	275
Inclination:	26.9515 deg
RA of node:	51.0499 deg
Eccentricity:	0.6033158
Arg of perigee:	158.5947 deg
Mean anomaly:	244.4550 deg
Mean motion:	2.05880591 rev/day
Decay rate:	-4.1e-07 rev/day²
Epoch rev:	2561
Semi major axis	26103.384 km
Anom period:	699.434557 min
Apogee:	35474.408 km
Perigee:	3977.240 km
Ref perigee:	3233.59623735
Sat Nov 8 14:18:34.906 1986 UTC	
Translate freq	581.0047 MHz
Invert:	1
Beacon:	145.8090 MHz

Satellite	OSCAR-12
Catalog number	16909
Epoch time:	86310.12801044
Thu Nov 6 03:04:20.102 1986 UTC	
Element set:	17
Inclination:	50.0121 deg
RA of node:	350.9795 deg
Eccentricity:	0.0011463
Arg of perigee:	78.9664 deg
Mean anomaly:	281.2427 deg
Mean motion:	12.44392562 rev/day
Decay rate:	-2.5e-07 rev/day²
Epoch rev:	1061
Semi major axis	7866.848 km
Anom period:	115.719110 min
Apogee:	1509.815 km
Perigee:	1491.779 km
Ref perigee:	3231.14559093
Thu Nov 6 03:29:39.56 1986 UTC	
Translate freq	581.8000 MHz
Invert:	1
Beacon:	435.7970 MHz

OSCAR-9
Wed Nov 19 01:16:31.643 1986 UTC:
Ascending node at 107.5 west
Nodal period: 94.24008 min
Longitude increment:
23.557151 deg w/orbit
Element set 957, epoch:
Fri Nov 7 00:15:50.435 1986 UTC

OSCAR-11
Wed Nov 19 01:19:02.149 1986 UTC:
Ascending node at 49.8 west
Nodal period: 98.54751 min
Longitude increment:
24.636923 deg w/orbit
Element set 181, epoch:
Tue Nov 4 18:02:31.680 1986 UTC

OSCAR-12
Wed Nov 19 01:24:31.808 1986 UTC:
Ascending node at 127.7 west
Nodal period: 115.65337 min
Longitude increment:
29.239380 deg w/orbit
Element set 17, epoch:
Thu Nov 6 03:04:20.102 1986 UTC

RS-5
Wed Nov 19 01:34:13.678 1986 UTC:
Ascending node at 58.9 west
Nodal period: 119.55228 min
Longitude increment:
30.015002 deg w/orbit
Element set 362, epoch:
Fri Nov 7 04:38:14.847 1986 UTC

AMSAT®

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Jan King, W3GEY, AMSAT VP-Eng., addresses a session of the American Astronautical Society in Boulder, Colorado 29 Oct. 86. Jan explained the Phase 4 concept to an enthusiastic group of space professionals.

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